

CAD and Performance Analysis

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We were initially given the roller assembly, which has not been weight optimized with the exception of the gears, which were optimized much earlier due to the density of steel. We therefore decided to optimize the side bars, side plates, and rollers for weight while maintaining a minimum factor of safety of 2. The rest of this document will be broken down based on component:

Belay Side Bar

The belay side bar was restrained at the bolt holes connecting it to the rest of the climber. The holes connecting to the U-bolts of the belay system were applied with 123N of force, as the climber would be subjected to by a climber of weight 25kg.

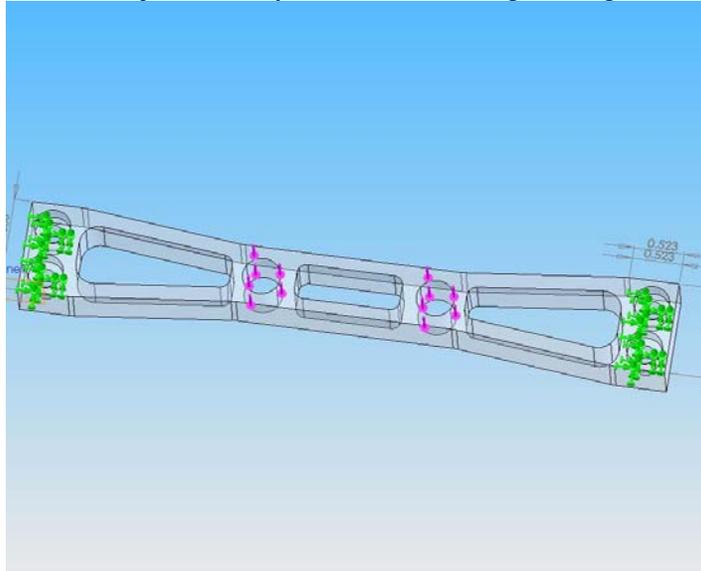


Figure 1: Belay Side Bar Forces

The resulting factor of safety distribution has a minimum factor of safety of 2.3 and the stress is fairly evenly spaced along the ribs of the bar.

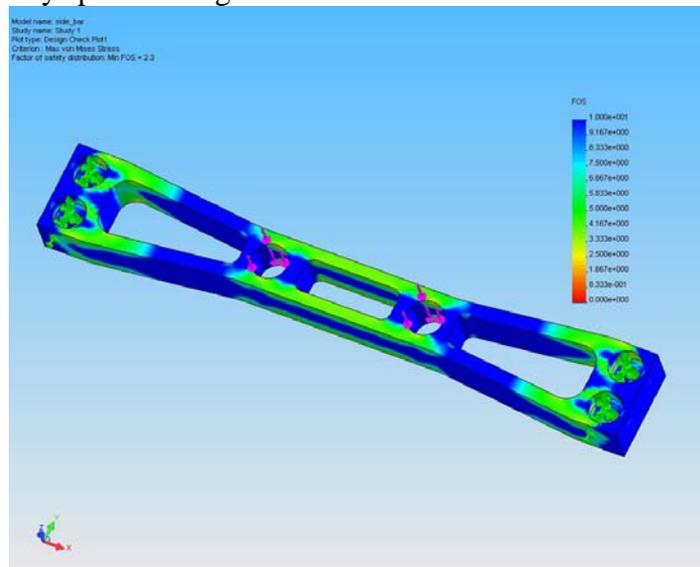


Figure 2: Belay Side Bar FOS

The resulting displacement distribution is as follows, with maximum displacement of $1.5e-3m$.

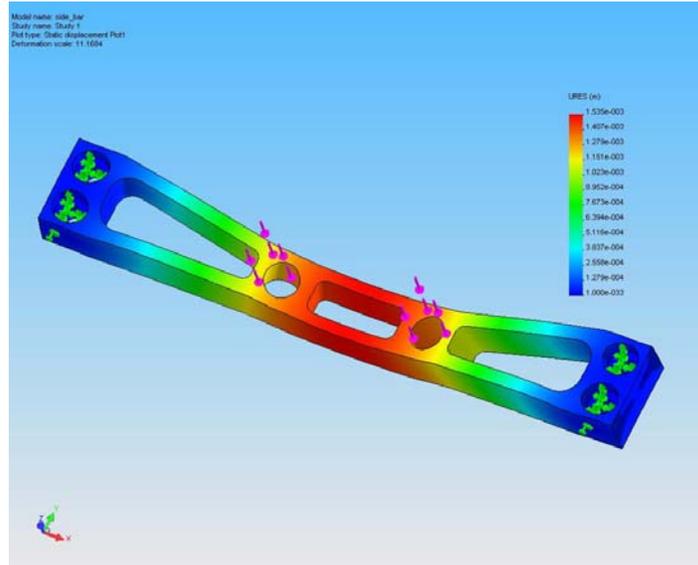


Figure 3: Belay Side Bar Displacement

The resulting factor of safety and displacement distributions fit the functional requirements and the even displacement of force ensures weight minimization.

Cross Side Bar

The cross side bar was restrained at the bolt holes connecting it to the rest of the climber. The hole connecting the cross bar to the motor holder is subjected to a 29pound outward force and a 10pound side force.

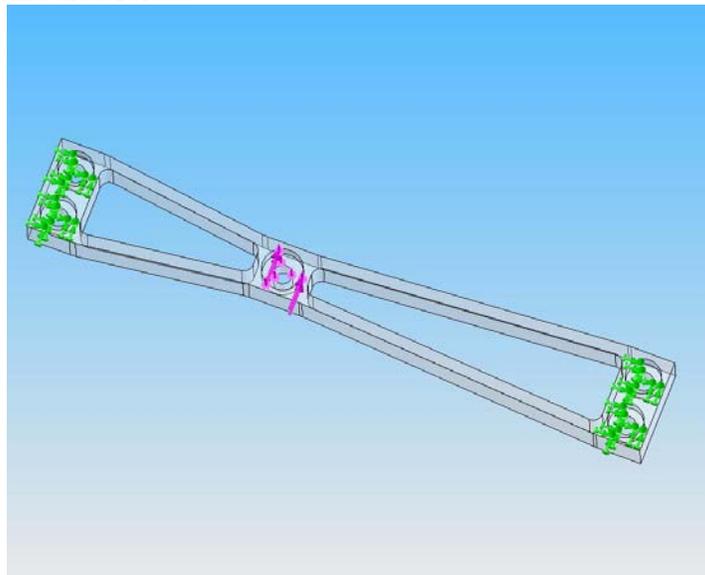


Figure 4: Cross Side Bar Forces

The resulting factor of safety distribution has a minimum factor of safety of 2.2 and the stress is fairly evenly spaced along the ribs of the bar. Although the middles of the ribs take less force, making them thinner would prove too risky.

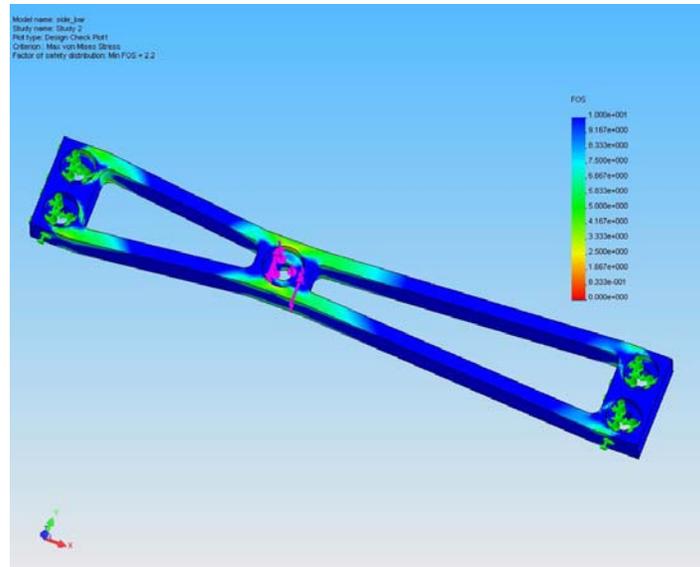


Figure 5: Cross Side Bar FOS

The resulting displacement distribution is as follows, with maximum displacement of $9.8e-4m$.

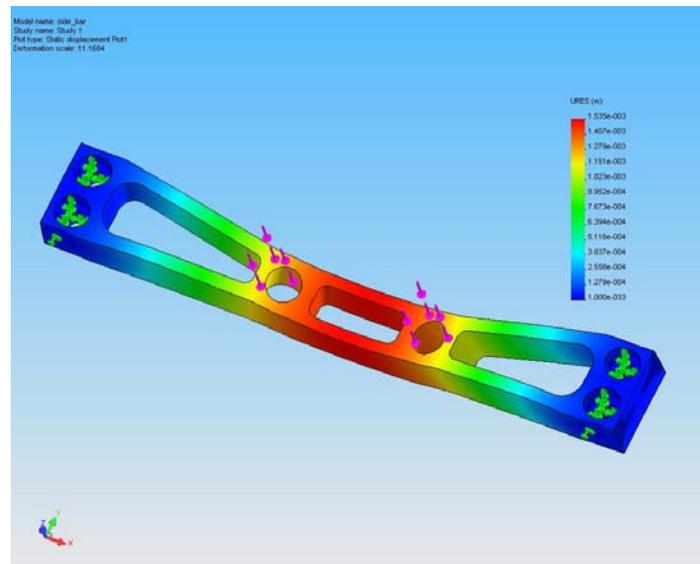


Figure 6: Cross Side Bar Displacement

The resulting factor of safety and displacement distributions fit the functional requirements and the even displacement of force ensures weight minimization.

Drive Rollers

The drive roller was restrained at the keyways connecting it to the drive axles. The surface of the roller is subjected to a $7N\cdot m$ torque, which is equivalent to half the weight of the climber, which is the force to which the rollers are subjected.

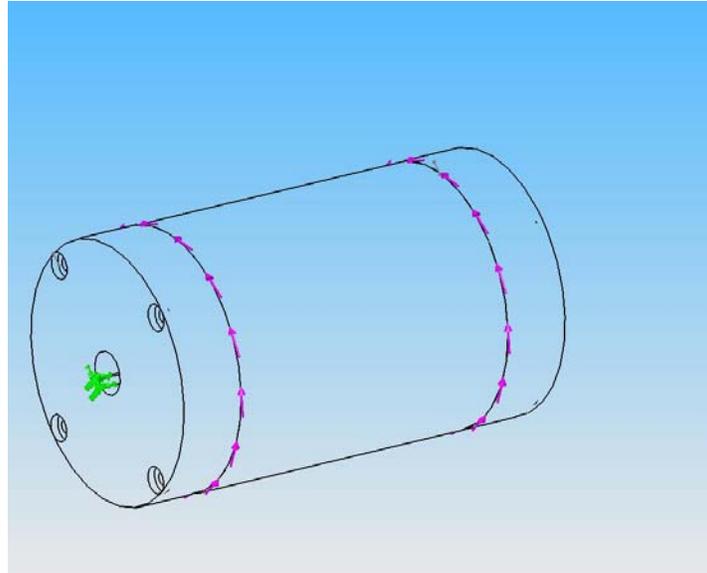


Figure 7: Drive Roller Forces

The resulting factor of safety distribution has a minimum factor of safety of 2.1 and the stress is as evenly spaced along the roller as is possible to ensure that mounting hardware can still be used to connect the roller caps to the roller body.

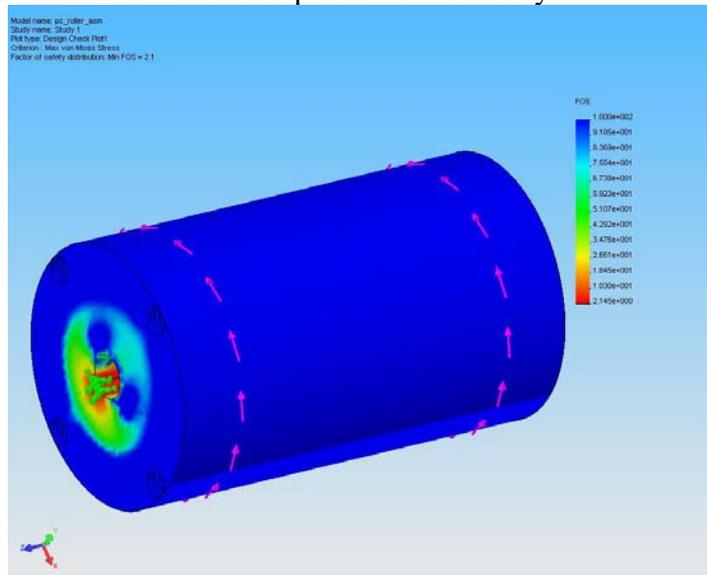


Figure 8: Drive Roller FOS

The resulting displacement distribution is as follows, with maximum displacement of $4.9e-4m$.

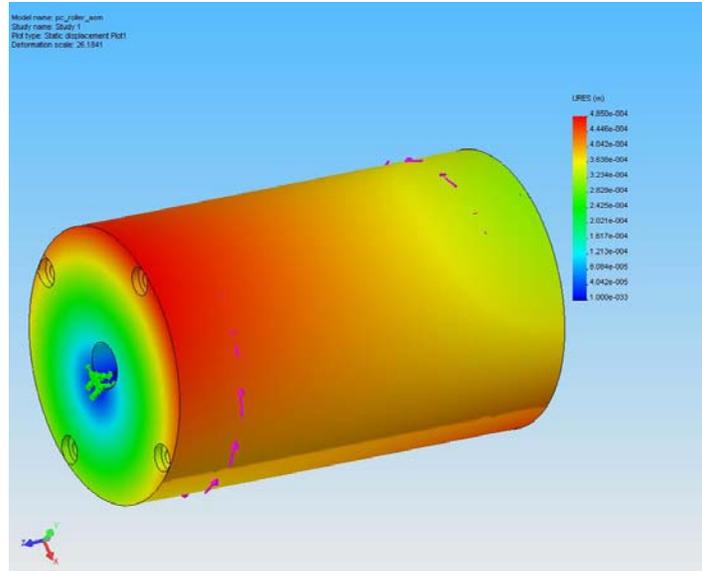


Figure 9: Drive Roller Displacement

The resulting factor of safety and displacement distributions fit the functional requirements and the relatively even displacement of force ensures weight minimization.

Guide Rollers

The drive roller was restrained at the keyways connecting it to the drive axles. The surface of the roller is subjected to a 7N-m torque, which is equivalent to half the weight of the climber, which is the force to which these rollers may be subjected.

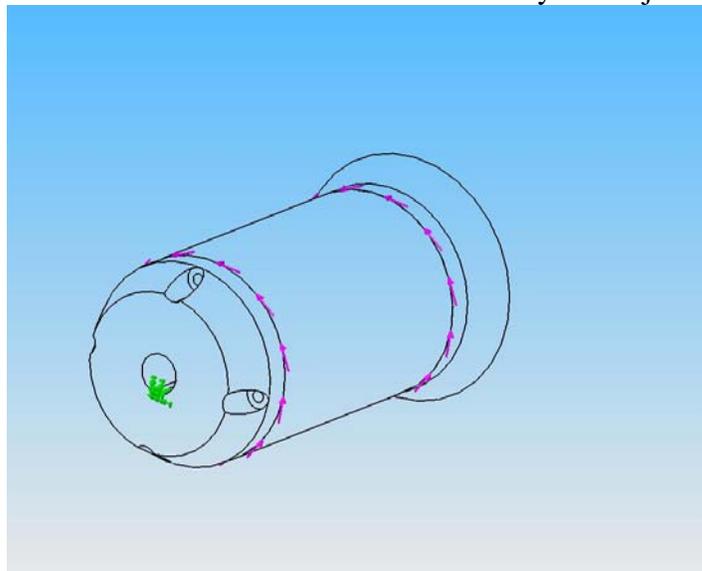


Figure 10: Guide Roller Forces

The resulting factor of safety distribution has a minimum factor of safety of 2.1 and the stress is as evenly spaced along the roller as is possible to ensure that mounting hardware can still be used to connect the roller caps to the roller body.

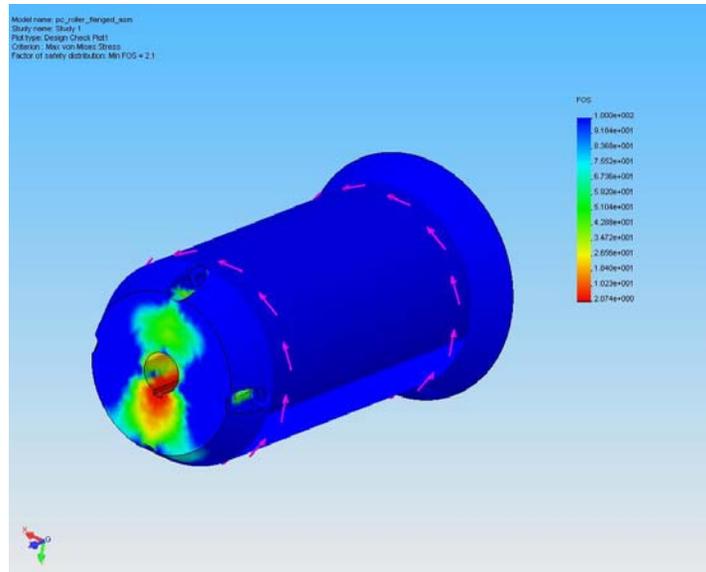


Figure 11: Guide Roller FOS

The resulting displacement distribution is as follows, with maximum displacement of $5.7e-4m$.

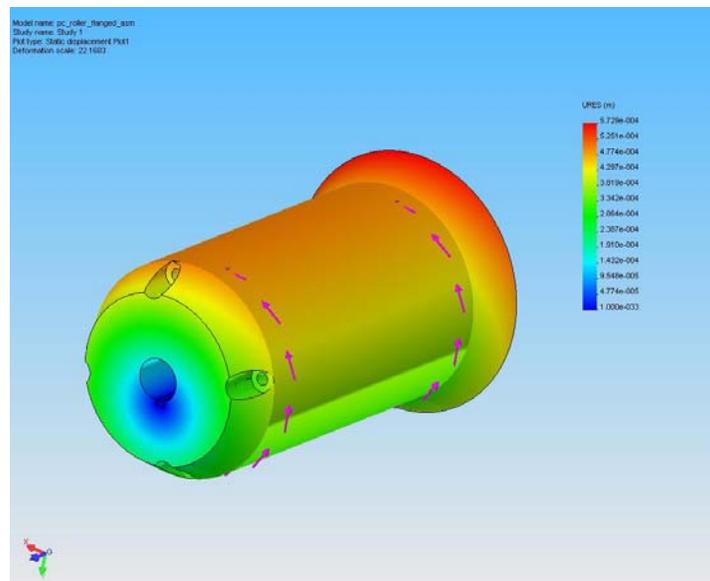


Figure 12: Drive Roller Displacement

The resulting factor of safety and displacement distributions fit the functional requirements and the relatively even displacement of force ensures weight minimization.

Side Plates

The side plates are restrained at all locations where the sidebars meet the plates. All of the axle holes are subjected to 7N-m of torque. This torque comes from the rollers pressing against the ribbon and is transferred to the side plates. The forces in the motor axle hole on the right plate or the slot on the left plate have a torque of 12 in-lb. All the axle holes have a downward force of 5 lb. The bottom of the plate experiences a downward force of 123 N (or 15 kg).

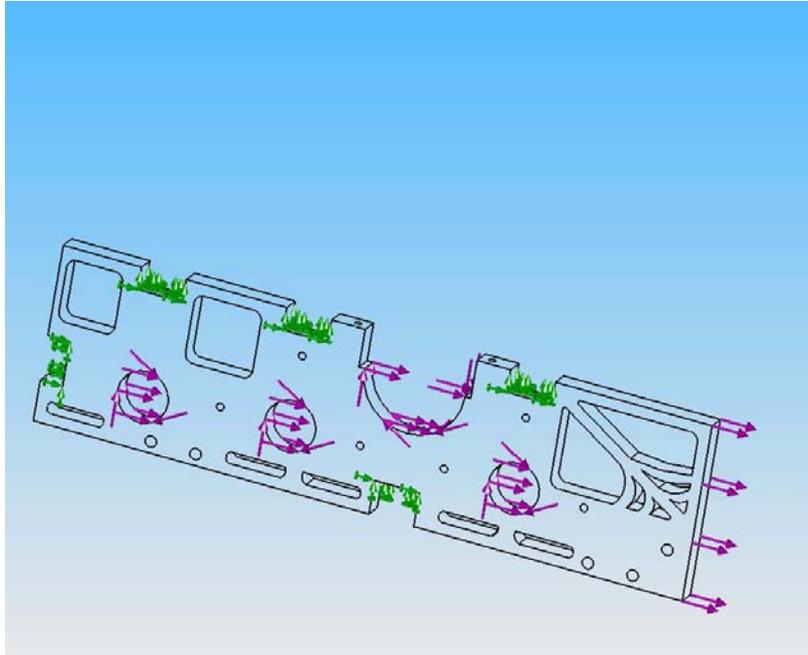


Figure 13: Side Plate Forces (Left)

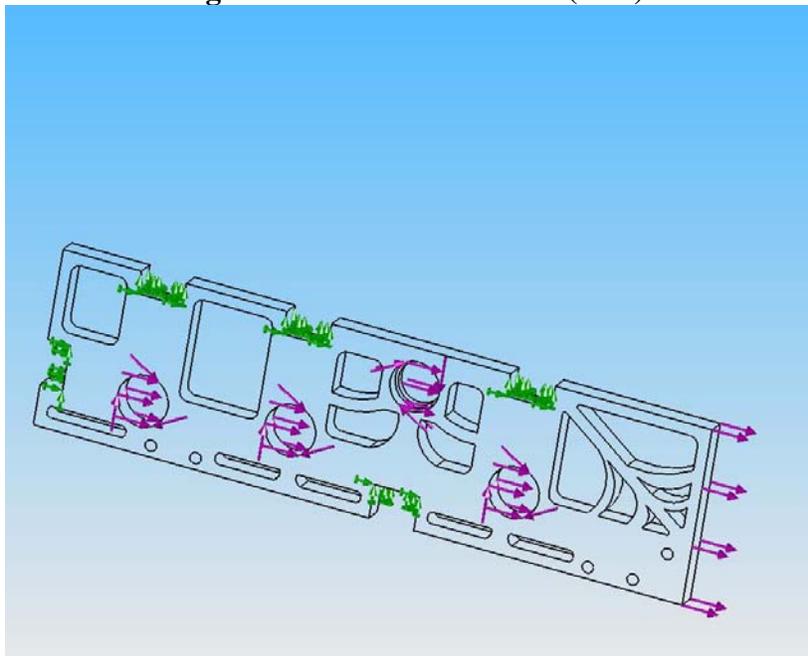


Figure 14: Side Plate Forces (Right)

The left plate has a minimum factor of safety of 20. This is a high factor of safety, much higher than the minimum required; however, the stresses are evenly spread out, with the lowest fos at of the corner of the bottom triangles.

The right plate has a minimum factor of safety of 17. The lowest fos is in the same position as with the left plate. Additional stress had to be spread from the motor axle in the center of the plate, which does not exist on the left plate.

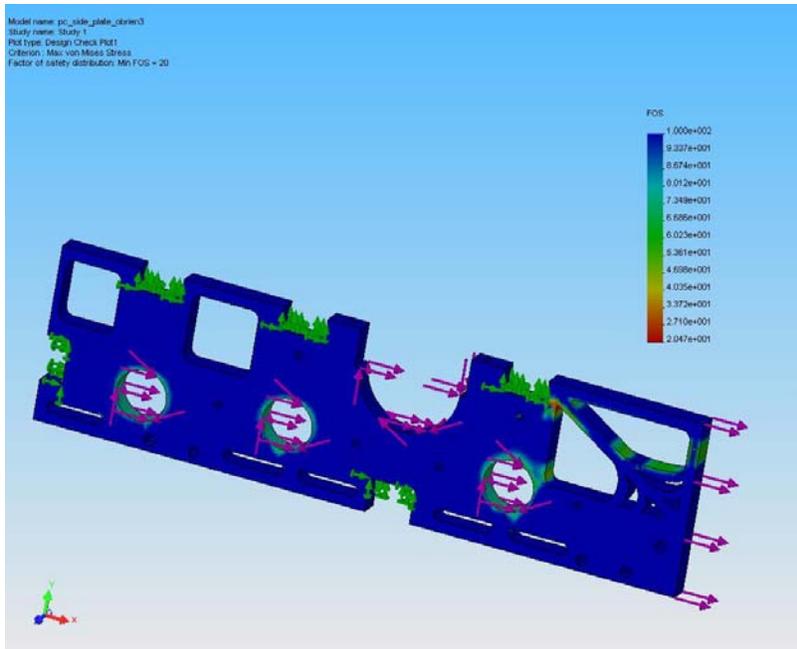


Figure 15: FOS (Left)

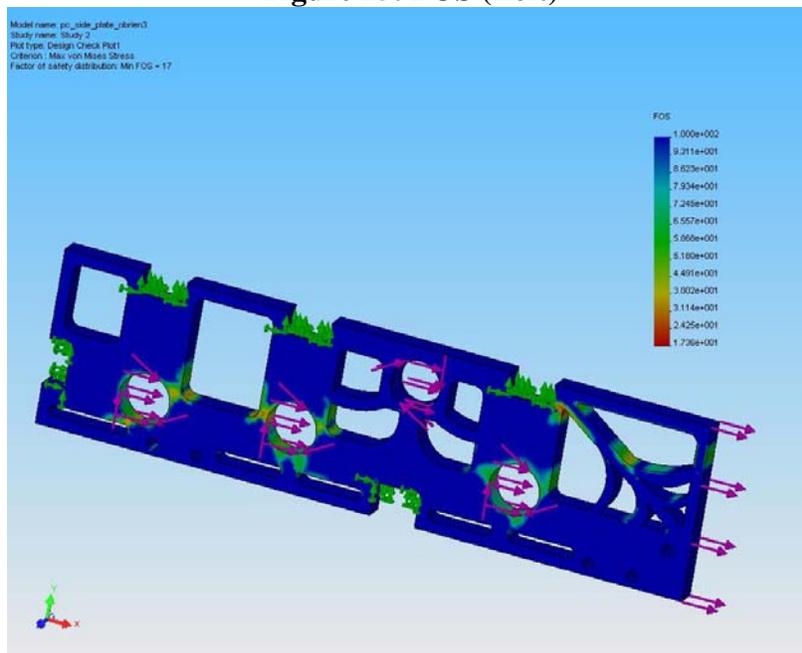


Figure 16: FOS (Right)

The largest amount of displacement occurs in the bottom corners, with a maximum displacement of $5.787e-5$ m and $6.078e-5$ m for the left and right plates respectively.

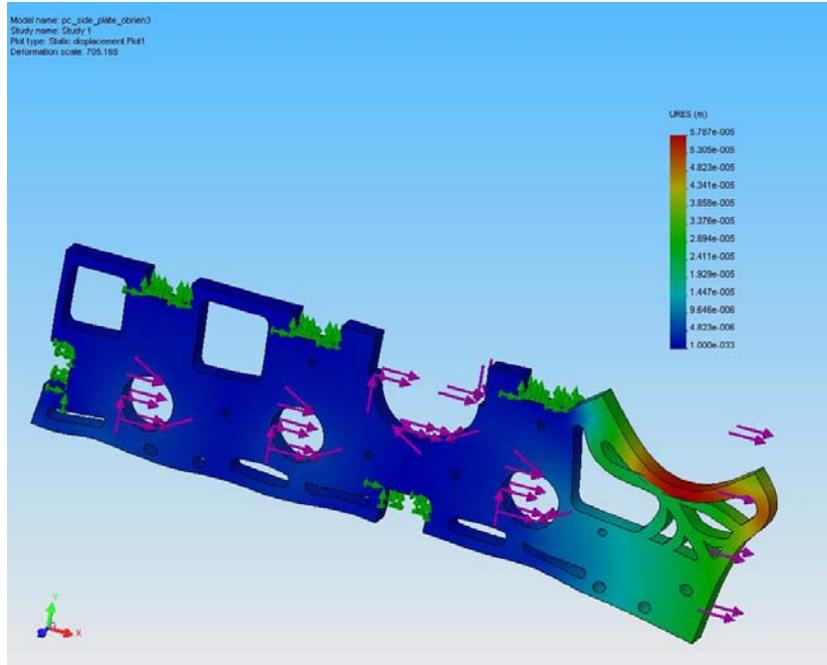


Figure 17: Displacement (Left)

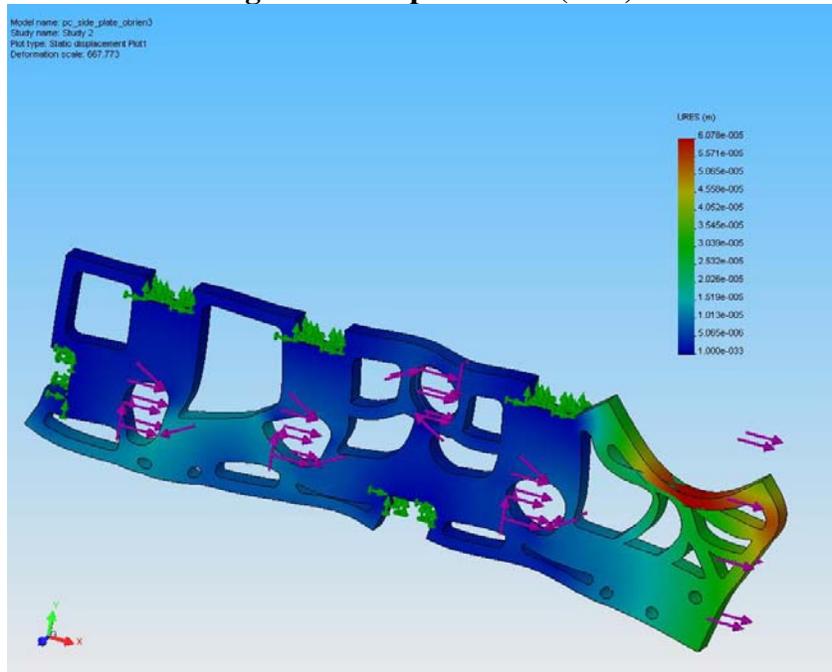


Figure 18: Displacement (Right)

With the high fos for both plates, the displacements and forces are kept to a minimum. This keeps the plates in the acceptable limits of the project.